S-curve trajectories of electronic money innovations

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A R T I C L E I N F O	A B S T R A C T
	This paper discusses the S-curve trajectories of electronic money innovations in today's payment system. It explores the development of ATM/cash cards, credit cards, electronic fund transfer at the point-of-sale (EFTPOS)/debit cards, smart cards and Bitcoin, the latest development of electronic money or digital money. The analysis is based on the technology S-curve and Schumpeter's model of economic development to understand the trajectories from physical money to virtual money—a path towards a cashless society. The results have shown parallel S-curve trajectories of electronic money innovations signifying a move from a cash-based economy towards a less cash society. The study sheds light on the future diffusion and adoption of Bitcoin innovation. © 2016 Elsevier Inc. All rights reserved.

1. Introduction

This paper explores the S-curve trajectories of electronic money innovations in attempts to understand if the global payment system is ready for a cashless society. Given that limited research has been carried out in respect of the service innovation (Miles, 1993, 1994, 2003, 2005), this study thus attempts to fill this research gap by focusing on the financial innovations and in particular the electronic money innovations. The paper explores the development of the global payment system from cash, notes and cheques to electronic money or digital money like ATM/cash cards, credit cards, electronic fund transfer at the point-of-sale (EFTPOS)/debit cards, smart cards and Bitcoin—the latest development of electronic money that has been pushed by countries around the world in attempts to be a cashless society.

The structure of the paper is as follows. Section 2 reviews the theoretical framework on service innovation and systemic innovation, technology S-curve and innovation diffusion, and Schumpeter's model of economic development. Section 3 describes the research design and methodology. Section 4 analyzes the landscape of the global payment system development. Section 5 explores the S-curve trajectories of the electronic money innovations. Section 6 concludes the paper and provides useful implications on the trends of global payment systems.

2. Theoretical framework

2.1. Service innovation and systemic innovation

Innovation is a complex process whereby many scholars have developed several approaches to define its nature. In the context of technology management, the term 'innovation' is defined in several ways. The definition encompasses a process of enhancing existing technology (Dosi, 1982; Nelson & Winter, 1977, 1982; Rosenberg, 1976, 1982) or a process of turning opportunities into

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practical use (Pavitt, 1984; Tidd & Bessant, 2009). In a more comprehensive approach, innovation is defined as an integrated process of enhancing the technology frontier, transforming this into the best commercial opportunities and delivering the commercialized product/process innovation in a competitive market with widespread use (Daft, 1982; Rothwell & Gardiner, 1985; Schott, 1981). The payment system is regarded as a service sector—a tertiary sector where the industries involve the transformation of material goods, people, or information (Freeman, 1991; Miles, 1993; Utterback, 1994; Voss, 1994).

Systemic innovation is another type of innovation which requires a number of complementary systems to realize the value of innovations. It is a set of interconnected innovations whereby an innovative coalition is necessary to achieve market acceptance. In other words, the systemic innovation is one where the benefits of an innovation increase disproportionately with the use and diffusion of the innovation among users and where most of the benefits are external to the particular innovator of the product or process and accrue to a wide range of users and uses (Chesbrough, 2003a, 2003b, 2011; Chesbrough & Teece, 1996). Many financial innovations are systemic innovations, for example, credit cards, international electronic fund transfer system, smart cards for financial applications (chip cards providing payment functionalities such as debits/credits, the smart card e-cash), travelers' cards (T&E cards) and cheque truncation (Wonglimpiyarat, 2006).

2.2. Technology S-curve and innovation diffusion

The innovation diffusion theory often deals with the innovation process. The innovation process characteristically exhibits an S-pattern. A review of various scholars' studies on the process of innovation diffusion is shown in Table 1. Utterback and Abernathy (1975) articulate the innovation process as S pattern. Vernon (1966)'s Product Life Cycle (PLC) is a classic model explaining the development as a pattern of product substitution (the S-curve pattern). The phases along the PLC reflect innovation diffusion—the progress of product/process innovations along the stages of introduction, growth, maturity and decline. Given the competitive environment of the innovation/diffusion process in the industry, Utterback and Abernathy (1975) developed a model of the dynamics of innovation—the innovation life cycle model—to describe the process of innovation and the degree of technological change. The innovation life cycle also provides a basis for technological forecasting. According to the study of the innovation process by Fisher and Pry (1971), they argued that when a new innovation reaches about 5% penetration of the potential application market, it provides a reasonable base for forecasting the speed and ultimate penetration achievable.

In the theories of economic growth and technological change, Abernathy, Clark, and Kantrow (1983) argued for the process of industrial de-maturity as the driving force of the industry evolution. They considered the nature of the innovation process as well as the competitive environment in which technology evolves to explain the progress of the industry. With respect to evolutionary theorizing on economic growth, they argued that technological change may alter the character of innovation and competition and over time affect the structure of the industry.

Table 1
Principal concepts of innovation diffusion.
Source: The author's design.

Scholars	Principal concepts of innovation diffusion
Utterback and Abernathy (1975)	The life cycle explains sources and directions of technological change. The life cycle explains the development of technology-related products and processes.
Fisher and Pry (1971)	Fisher and Pry offer a classical model for forecasting innovation diffusion. Their study is focused on the diffusion process of product innovations as well as the substitution rate of technological change.
Gort and Klepper (1982)	The study measures and analyzes the diffusion of product innovations. Their study divides the life cycle of the new product industries into five stages. The study provides a basis for the development of a theory of the evolution of industries.
Abernathy et al. (1983)	They view the innovation process as a process of industrial de-maturity. They argue, from the perspective of evolutionary theory on economic development, that technological change may alter the character of innovation and competition and over time affect the structure of the industry.
Rogers (1962, 1995, 2003)	The innovation development process comprises six stages: • problem definition • research (basic and applied) • development • commercialization • adoption and diffusion • consequences
Cooper and Kleinschmidt (1990)	The innovation development process of the manufacturing industry comprises: • preliminary assessment • detailed investigation (problem definition) • development • testing and validation • commercialization
Peres, Muller, and Mahajan (2010)	They study the diffusion processes of new products and services. They view the innovation diffusion as a process of market penetration whereby the launch of new products and services is driven by social influences.
Guseo and Guidolin (2015)	Their study is focused on the innovation diffusion—the new product life cycle. They propose a multimodal model to the life cycle of the compact cassette format for pre-recorded music in Italy.

Among the different approaches regarding the dynamics of innovation, Rogers (1962, 1995, 2003) offers one of the most important models of innovation diffusion based on the well-established theories in social science, psychology and communications. In this study, the analysis of S-curves in the payment system and the discussions on the process of innovation will be based on the concept of innovation life cycle since the model provides a basis to understand innovation diffusion—a process of commercialization and market acceptance.

2.3. Schumpeter's model of economic development

In Schumpeter's theory, the successive industrial revolutions are based on the transformation of the economy by new technologies. According to Schumpeter (1939, 1967), the phenomena of 5 Kondratieff cycles engender waves of technological change. In other words, Schumpeter's long-wave theory explains the waves of economic development whereby the shift from an existing business cycle to a new one leads to the growth of industrializations. The Schumpeterian view of 'creative destruction' emphasizes discontinuity of economic development. That is to say, the process of creative destruction brings about the economic growth of which the emergence of new products/process innovations does not grow out of the old ones but eliminates them (Schumpeter, 1939, 1967).

Schumpeter (1939, 1967) argued that finance and financial institutions are the mainstream of innovation system as well as crucial determinants of the economic performance. It is interesting to see that the Schumpeterian view of economic development has set the stage to develop a new paradigm further (Dosi, 1982; Nelson & Winter, 1977, 1982; Pavitt, 1986, 1989; Rosenberg, 1976, 1982). The development cycle of industries is represented by revolutionary shifts in which one paradigm displaces another, leading to surges of economic growth (Kuhn, 1970; Schumpeter, 1939, 1967).

Tushman and Anderson (1987) also describe patterns of technological change as a cumulative process until punctuated by discontinuous innovations. This causes technological shifts, either competence-enhancing or competence-destroying. Competence-enhancing discontinuities are order-of-magnitude improvements based on cumulative experience in the use of earlier vintages of technology in contrast to competence-destroying discontinuities which require the mastery of new technology, skills, abilities and knowledge in both the development and the production of the product (Abernathy & Clark, 1985; Abernathy et al., 1983). The argument of Tushman and Anderson (1987) is in line with Freeman and Perez's fourth taxonomy of innovation (changes of techno-economic paradigms); and Gallouj and Weinstein's (1997) radical innovation, arguing for radical replacement innovations.

Whereas Schumpeter conceptualized a qualitative transformation of the economy, Freeman and Perez (1988) made further attempts to define the trajectories as conditions of new waves. Freeman and Perez (1988) argued that the process of economic development is radical and causes a technoeconomic paradigm. According to their studies, a technoeconomic paradigm is a cluster of interrelated technical, organizational and managerial innovations that affects the whole economy. According to Freeman and Perez (1988), the three trajectories characterizing a change in technoeconomic paradigm are:

(i). The fall in cost
(ii). Unlimited availability of supply over long-time periods
(iii). Prevailing use in a large number of products or processes

Taking into account the adoption and diffusion of Bitcoin, the analysis in Section 4 will discuss whether Bitcoin would bring about the shift of economy; particularly the payment industry based on the concept of technoeconomic paradigm by Freeman and Perez (1988).
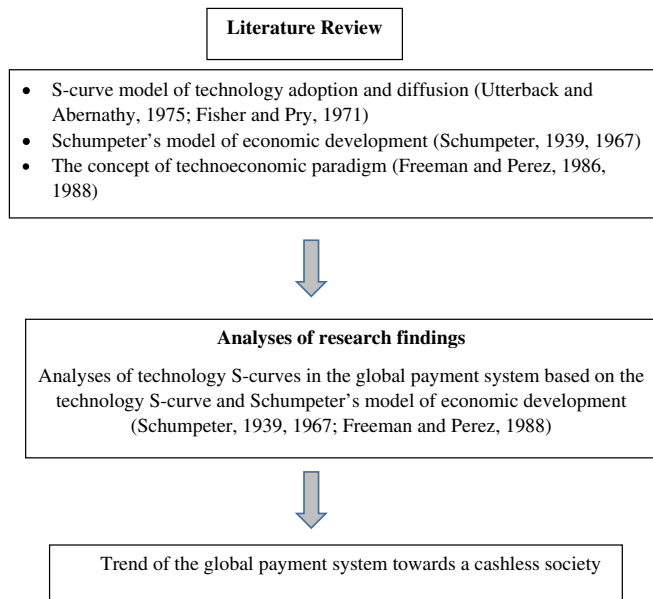
3. Research design and methodology

Currently, there is scarce research on service innovation (Miles, 1993, 1994, 2003, 2005). Furthermore, financial innovation in particular has received little attention. Given the limited research in financial innovation, this study attempts to fill the research gap by exploring financial innovation in the payment system. The research employs a case study methodology (Eisenhardt, 1989; Yin, 2013). The research aims to understand the S-curve trajectories of electronic money innovations and the trend towards a cashless society.

This study has applied the S-curve model of technology adoption and diffusion by Utterback and Abernathy (1975), Fisher and Pry (1971) and Schumpeter's model of economic development (Schumpeter, 1939, 1967) to analyze the process of technological change with regard to the future paradigmatic shift of the payment system. Fig. 1 provides the research framework of this study. The overarching goal of this research is to understand the S-curve trajectories of electronic money innovations including Bitcoin innovations. The qualitative analysis on the process of Bitcoin adoption and diffusion is supported by interview data to interpret the research findings.

4. Trends of the global payment system development

Taking into account the S-curve trajectories of the payment system, it is argued that e-payments are set to be a huge growth market in future payment systems. Fig. 2 shows the trends of the global payment system development. The outside circle represents the total market of the payment industry. The inner circle represents the market share of each payment innovation. The left figure presents the market status of payment innovations at present. It can be seen that the innovation of ATM cards, credit cards
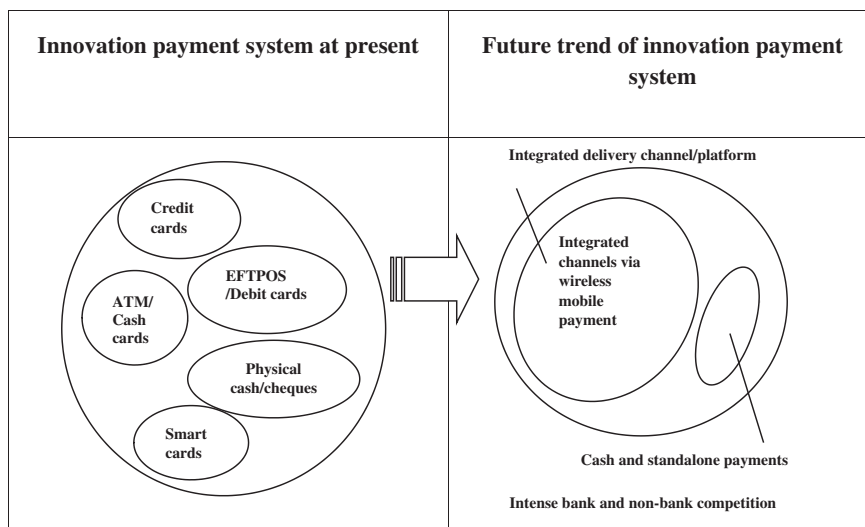
Literature Review

- S-curve model of technology adoption and diffusion (Utterback and Abernathy, 1975; Fisher and Pry, 1971)
- Schumpeter's model of economic development (Schumpeter, 1939, 1967)
- The concept of technoeconomic paradigm (Freeman and Perez, 1986, 1988)

Analyses of research findings

Analyses of technology S-curves in the global payment system based on the technology S-curve and Schumpeter's model of economic development (Schumpeter, 1939, 1967; Freeman and Perez, 1988)

Trend of the global payment system towards a cashless society

Source: The author's design

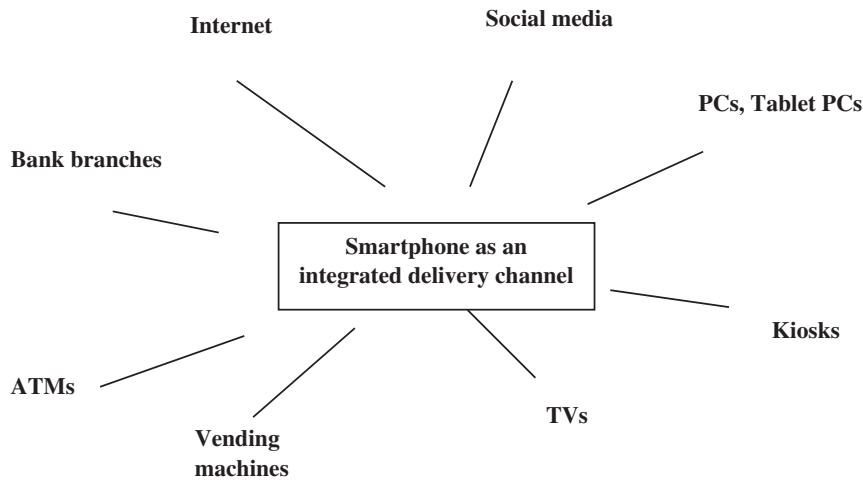**Fig. 1.** Research framework. Source: The author's design.

and EFTPOS/debit cards dominates the global payment system with the prevailing use of physical cash and cheques (Paxson & Wood, 1998).

The arrow pointing from the left to the right reflects the trend where the payment innovations finally exploit an integrated delivery channel/platform to converge payment capabilities and electronic payment services. The future trend in the payment market is the integration of cards and mobile payment—integration of card functionalities including ATMs/credit cards/debit cards, e-cash and virtual currency—to form a single integrated global payment network. In the light of growing e-businesses, banks and non-banks compete to invest in multi-delivery channels to provide a substitute for traditional banking delivery channel with an aim to develop a close relationship with the target customers (Fig. 3). By integrating the delivery channels, strong ownership of customers would provide preferential access to follow-on products and by the same token deny access to competitors even where they have significantly better products and services.

Innovation payment system at present	**Future trend of innovation payment system**

Credit cards

EFTPOS /Debit cards

ATM/ Cash cards

Physical cash/cheques

Smart cards

Integrated delivery channel/platform

Integrated channels via wireless mobile payment

Cash and standalone payments

Intense bank and non-bank competition

Source: The author's design

Fig. 2. The development of payment innovations.

Internet   Social media

PCs, Tablet PCs

Bank branches

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┌─────────────────────────┐
│   Smartphone as an      │
│ integrated delivery channel │
└─────────────────────────┘
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Kiosks

ATMs

Vending
machines   TVs

Source: The author's design

Fig. 3. Integrated delivery channel of the payment system.

Fig. 3 also reflects the trend of the future payment system towards integrated delivery channel/platform using the mobile capacity—mobile money. According to the statistics by the International Telecommunication Union, the mobile penetration rate in 2015 had reached 97 percent globally with 7 billion mobile subscriptions. With the power of mobile phone technology, mobile money is growing and opening up the mobile commerce (m-commerce) opportunity for banks. Mobile phones also provide a new delivery channel for banks to offer financial services to their clients. Fig. 4 portrays the landscape of the payment system in a global context showing the development of payment innovations from cheques to ATM/cash cards, credit cards, electronic fund transfer at the point-of-sale (EFTPOS)/debit cards, smart cards and Bitcoin.

Bitcoin, the latest payment innovation, opens up the m-commerce opportunity. Based on the decentralized digital-payment system providing online payment solutions, this new innovation of digital currency allows users to transact directly without needing any payment intermediaries. Interestingly, the Bitcoin wallet enables online access to virtual banking. At present, Bitcoin is gaining in popularity where there is hope that the society would shun physical cash and adopt digital money with the aim of progressing towards a cashless society.

5. S-curve trajectories of the electronic money innovations

The present payment landscape is now evolving towards mobile payment systems due to widespread smartphone usage and the growing number of mobile broadband subscriptions (Fig. 5). Bitcoin is currently seen as the latest electronic money or digital money that might revolutionize the payment system. Fig. 6 shows the growing share of Bitcoin ATM adoption worldwide. While being widely adopted in the North American and European countries, Bitcoin is struggling to gain acceptance in other continents including Asian countries. The analyses based on the technology S-curve and Schumpeter's model of economic development (Freeman & Perez, 1988; Schumpeter, 1939, 1967) have shown that, at present, the swing of S-curves is not strong enough to cause a paradigm shift.

(i). The fall in cost
The transaction cost is 0.045 BTC[1] (or USD 17). The cost to the network is 0.03 BTC per BTC transferred. The Bitcoin innovation has low transaction fee of 0.0005 BTC per 1 transaction compared to other financial transactions (compared to credit card transaction fee of 3%–5% per transaction value) which would help achieve widespread usage.

(ii). Unlimited availability of supply over long-time periods
Bitcoin is a virtual currency created by software for exchanging value without the use of intermediary banks. Given its characteristics as an open source software, this provides unlimited supply since the software developers can use the open-source code to develop Bitcoin applications.

(iii). Prevailing use in a large number of products or processes
Given that the innovation is not backed by any government and the innovation is vulnerable to manipulation as well as speculation, many countries are reluctant to accept Bitcoin. The major problem concerning lack of secure infrastructure has hindered Bitcoin innovation to achieve widespread use.

[1] BTC stands for Bitcoin. It is the unit of digital currency of the Bitcoin system.
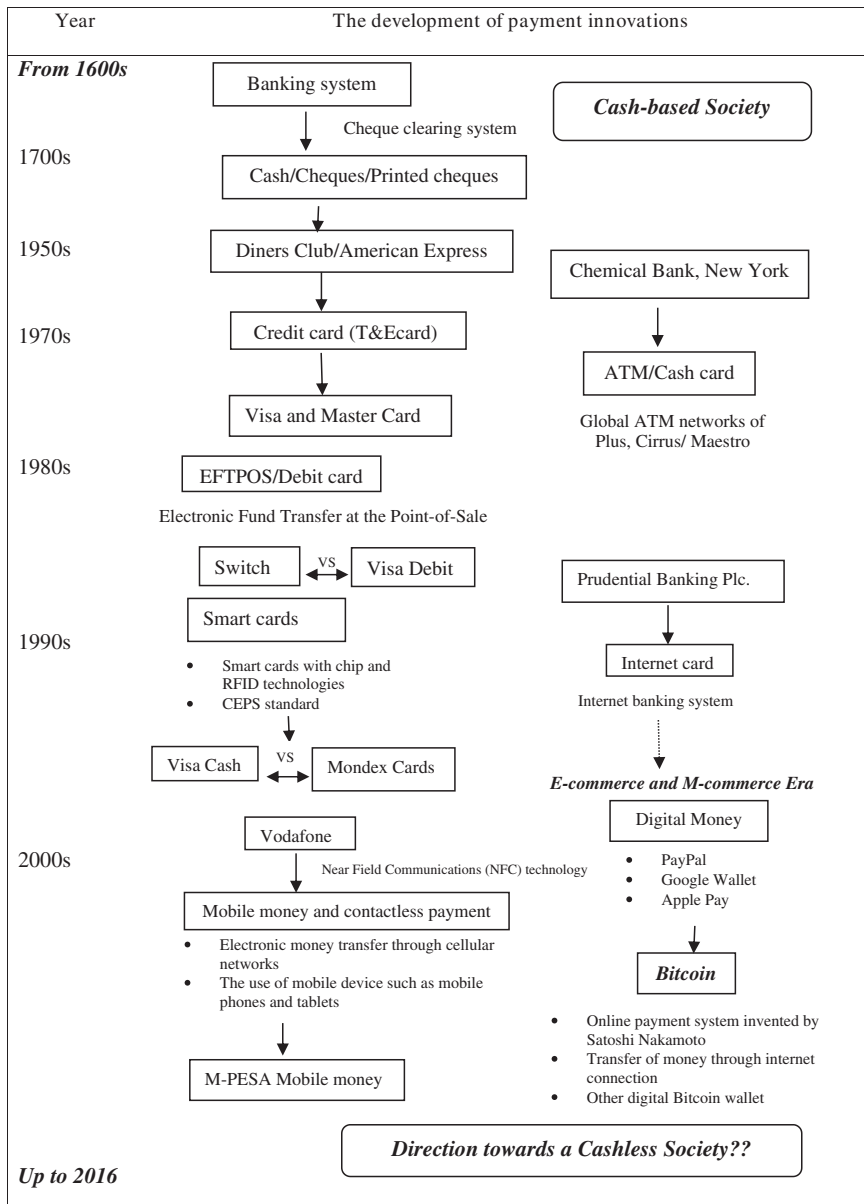
**Fig. 4.** Landscape of the global payment system.

Based on the technology S-curve and Schumpeter's model of economic development, Fig. 7 analyzes the process of technological change of technology S-curves and the trend towards a cashless society. It can be seen that the technological evolution progresses from physical cash and cheques to electronic cash of ATM/cash card, credit card, EFTPOS/debit card, mobile money (or electronic money transfer through cellular networks) and the latest digital money innovation of Bitcoin. It is argued that the process of technological change of the payment innovations shows a parallel of S-curves.

Taking into account the trend of a cashless society, Bitcoin innovation has not yet disrupted the global payment system due to many implementation problems. The major problems are that the Bitcoin innovation is not backed by any government and there are problems of insecure payment infrastructure. The parallel S-curves underlying the process of technological change in the payment system as shown in Fig. 7 have shown that the progress of the payment system is evolutionary. That is to say, the parallel S-curve trajectories of electronic money innovations signify a move from a cash-based economy towards a less cash society. The global payment system is progressing towards a less cash economy (not a process of revolution or creative destruction) and thus a cashless society seems unlikely in the near future.
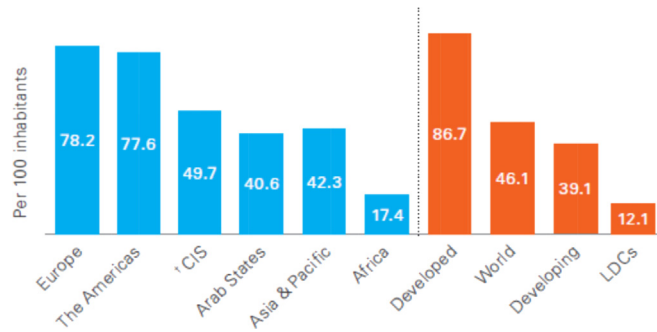
Source: International Telecommunication Union

Fig. 5. The percentage of mobile broadband subscriptions in 2015. Source: International Telecommunication Union.
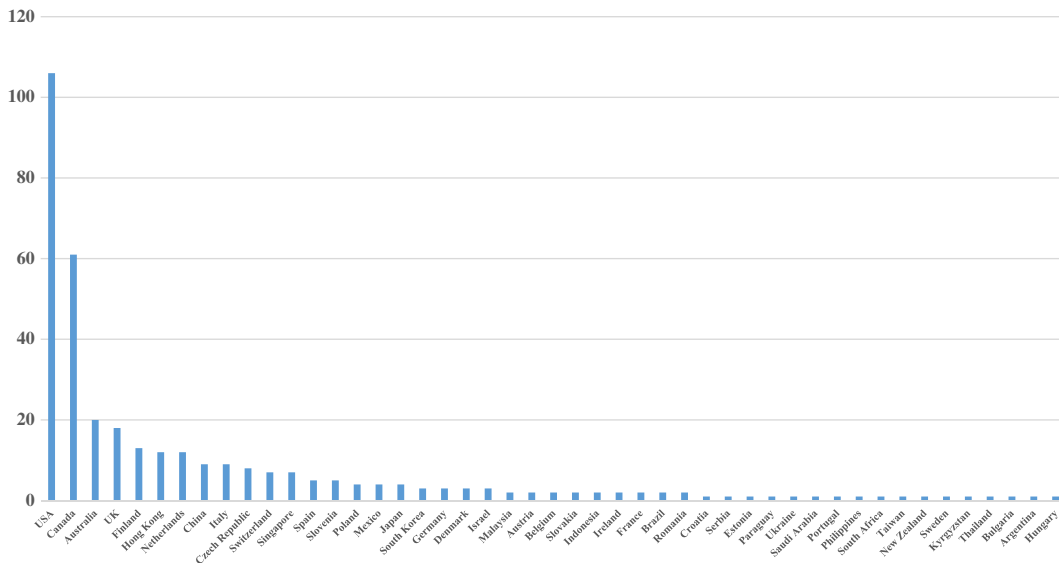

Source: The author's design (compiled from Coin ATM Radar)

Fig. 6. Share of Bitcoin ATM adoption worldwide.

At present, Bitcoin is struggling to revolutionize the global payment system since there are many issues hindering Bitcoin's adoption. For example, in China, the central bank has barred financial institutions from handling Bitcoin transactions and restricted the transfer of Bitcoins. In Thailand, Bitcoin is not authorized to operate as the Bank of Thailand argues that Bitcoin exchange operations do not fall under the scope of the Ministry of Finance regulation. In Malaysia, Bitcoin is not recognized as a legal tender where the central bank advises the users to be aware of the risks associated with Bitcoin usage. In South Korea, there are no laws regulating the use of Bitcoin at present. In Indonesia, the central bank of Indonesia sees Bitcoin as a money laundering threat and cybercrime.[2] It can be seen that as Bitcoin is not regulated by banks, many countries have not yet decided in terms of planning to issue regulations on Bitcoin innovation.

The views of the Bank of Thailand provide reflection example of the Asian situation where Bitcoin is not accepted as a currency. According to views of the Bank of Thailand, it states: "…Bitcoin is not recognized as legal tender. It is not accepted as a means for debt settlement. Bitcoin has no intrinsic value in itself. Its value varies with the demand and supply of traders who purchase or sell Bitcoins. Therefore, the price or value of Bitcoin can change rapidly and Bitcoin may eventually have no value when nobody wants it. We (the Bank of Thailand) therefore have announced that Bitcoin is illegal. It is a breach of monetary law and we ban buying and selling of Bitcoin. We forbid the use of Bitcoin in exchange of goods or services as well as the exchanges between Bitcoin and other currencies in Thailand…".

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[2] See further information from The Law Library of Congress (2014), Regulation of Bitcoin in Selected Jurisdictions Report, Global Legal Research Center.
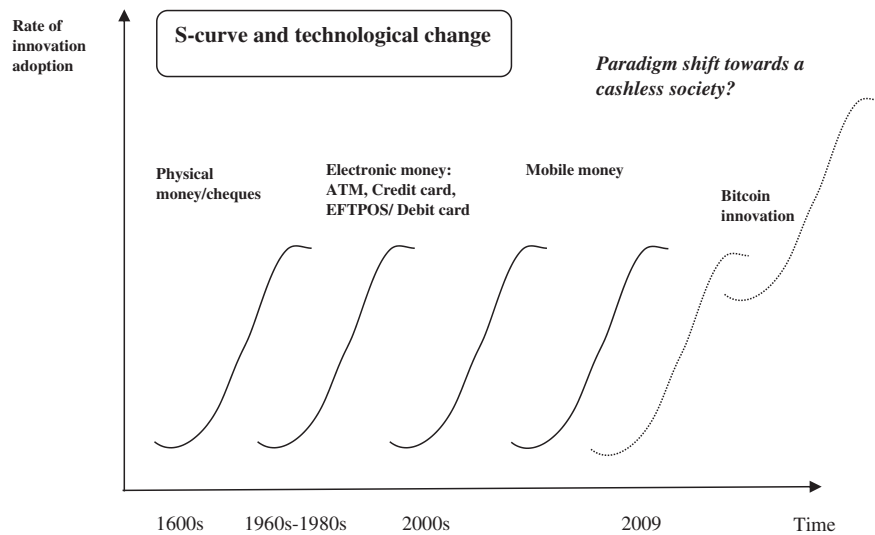
Source: The authors' design, based on Utterback and Abernathy (1975) and Fisher and Pry (1971)

Fig. 7. Technological change in the payment system and potential adoption of Bitcoin. Source: The authors' design, based on Utterback and Abernathy (1975) and Fisher and Pry (1971).

Concerning the slow adoption of Bitcoin innovation, the major problems are the competing mining protocol standards which hinder interoperable payment systems and the insecure operation which make Bitcoin digital wallets vulnerable to theft and loss. Furthermore, the issue of unidentified persons performing transactions has raised concerns over financial crime. At present, there are insurmountable problems of insecure computer and internet infrastructure as happened in the case of Mt. Gox where Bitcoin totaling USD 370 million was stolen.[3] As the currency is not issued or backed by the government, the central banks of countries around the world hesitate to accept Bitcoin, hindering the progress of Bitcoin adoption.

The analyses of findings in this paper have shown the development of a payment system whereby many financial innovations have been launched in attempts to move from a cash-based economy towards a less cash society (the technological change does not reflect a process of revolution nor creative destruction). To improve the adoption rate of Bitcoin innovation, it needs a secure payment platform and information and communications technology (ICT) infrastructure.

6. Conclusions

This paper discusses the S-curve trajectories of electronic money innovations in today's payment system. The analyses have shown parallel S-curve trajectories of electronic money innovations signifying a move from a cash-based economy towards a less cash society. The analyses of the payment systems have shown an evolutionary path on the development of ATM/cash cards, credit cards, electronic fund transfer at the point-of-sale (EFTPOS)/debit cards and smart cards. Concerning the latest development of electronic money or digital money of Bitcoin, the swing of S-curves does not seem to be strong enough to cause a paradigm shift due to major problems of not being backed by the government and insecure infrastructure (the third factor of not achieving prevailing use in a large number of products or processes according to the theory of techno-economic paradigm shifts by Freeman & Perez, 1988). Therefore, a cashless society seems unlikely in the near future.

The research makes theoretical and empirical contributions to the studies of financial innovation in an attempt to fill the gap of research in service innovation. The analysis of the global payment systems has shown an evolutionary path towards a less cash economy (not a revolutionary technological innovation nor creative destruction according to Schumpeter's model of economic development; Schumpeter, 1939, 1967). The results signify the direction towards a less cash economy rather than a cashless society. The study provides useful implications to support the diffusion of Bitcoin innovation as follows:

(i). At present, there are concerns over the security of a virtual cryptocurrency of Bitcoin. To achieve widespread adoption, Bitcoin needs a secure ICT and payment infrastructure. It is argued that the central bank of all countries enact monetary policies to solve the problems of security incidents. Importantly, the governments should play a greater role in concocting regulations to improve the legitimacy of Bitcoin.

(ii). Bitcoin poses a challenge of systemic innovation. The new digital currency needs global collaboration among developers to provide a powerful platform to promote widespread adoption.

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[3] Mt. Gox was the major Bitcoin exchange in Shibuya, Tokyo, Japan. After the operation fraud, trading was suspended. The exchange was later shut down and filed for bankruptcy (*The Guardian News*, 21 March 2014).

(iii). The Bitcoin currency may change the future of banking in developing countries as Bitcoin allows access to a payment system in areas where the banking infrastructure is not developed. In this respect, Bitcoin might revolutionize the payment system in the future.

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